(Fungi)
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By C. CROSSLAND, F.L.S.

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BRITISH MUSEUM (NATURAL HISTORY) BOTANY

FUNGI.

By C. CROSSLAND, F.L.S.

It is well known that the study of the lower Cryptogams —Lichens, Algæ and Fungi—has received much less attention from botanical students generally than have the higher Cryptogams—Ferns, Mosses and Hepatics, and the Phanerogams or flowering plants.

Doubtless there are various reasons accounting for this ignoring of the lower forms of vegetation :—(1) They are of little economic interest (apart from the destructive parasitic fungi) compared with the higher forms. (2) They are less attractive to the superficial and casual observer, and the smaller ones require special effort to seek them out. (3) In Fungi, the characteristics are less distinct and much more difficult to define ; their appearance is most uncertain ; the season of many of the fleshy species comparatively short ; and further, many perish so rapidly that the opportunities for their study are considerably curtailed. Other reasons will suggest themselves to the reader.

Fungi, in one form or another, occur all the world over where animal or vegetable substances are to be found on the face of the earth, and sometimes even in water. It will be made clear later on that they are entirely dependent on either plants or animals for their existence.

At present upwards of 52,000 species are known to exist in the universe, yet there are immense areas still virgin ground to the mycologist or the mycological collector. Their nature does not conduce to their receiving much attention by explorers generally. In years to come, the number of known species will certainly be considerably increased by further investigations. A little over 5,200 are indigenous to Britain ; about half of this number have already been found in Yorkshire (vide the recently published "Yorkshire Fungus Flora") ; new species are constantly being brought to light, and doubtless others await discovery.

An absolute accurate definition of Fungi is difficult to give. The nearest approach is "they are cellular cryptogamic plants, devoid of chlorophyll, either saprophytes or parasites, deriving their nutriment by means of a mycelium, from a dead or a living matrix." Being devoid of chlorophyll they are unable to elaborate their own food and building material, hence must needs derive it second hand, in an already organized form, either as parasites, from living organisms, animal or vegetable, or as saprophytes, from their decaying remains. The great majority belong to the latter class. Some species possess the faculty of leading either a parasitic or a saprophytic life as opportunity offers, *e.g*, the honey agaric—*Armillaria mellea* ; the squarrose Pholiota—*P. squarrosa* and others. Doubtless their parasitic habits are of more recent acquirement than their saprophytic propensities.

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If Fungi have a mission at all in the economy of Nature, it is that of helping to break down, or disintegrate, dead organic structures not otherwise disposed of, which, after having filled their allotted place in life, await the natural processes of decomposition. This work is accomplished more especially by the ceaseless activity of numerous species of bacteria, and under their action, fungi themselves are in turn decomposed.

The structure of Fungi is rudimentary in comparison with that of the higher cryptogams. Their tissues, no matter how compact and hard, or soft, light and "fluffy," consists simply of rows of superimposed cells known as *hyphæ*. These hyphæ are packed more or less closely together side by side, or are lightly but intricately interwoven, according to the species. The cells may be long and continuous without transverse septa or dividing membranes, or they may be short with closely repeated divisions. The hyphæ, often branched, may be linear throughout, or the component cells may be irregularly swollen, or even globose. The walls may remain thin and the lumen or cavity wide, or they may be thick and the lumen almost obliterated; those of the latter kind occur, as one would expect, in the harder, more closely set tissues, and of the former in the softer and lighter structures. In some species the hyphæ form what are known as clamp connections between two adjoining cells; one cell puts out a short protuberance which bends over the septum and its point fuses with the lateral wall of the neighbouring cell, thus increased communication is established between the two by this semi-circular loop. There are other details into which we cannot enter for want of space. Some writers consider that the loop facilitates the transport of the nutrient fluids along the hyphæ.

The *sporophores* or fructifications exhibit an almost infinite variety of form. They may be roughly divided into two sections —simple and compound. The former are represented by the Mucors and other minute moulds which develop their spores on single hyphæ arising from the *mycelium*; the latter, by the Gastromycetes (puffballs), Agaricaceæ (toadstools), Polyporaceæ, Clavariaceæ, Pyrenomycetes, Discomycetes, etc.

The mycelium or spawn represents the vegetative system, and may be considered as the real Fungus-plant. It develops within the matrix of living or dead wood, or herbaceous plants, or ramifies among dead leaves and humus. The structures we know as fungi, and see pushing their way out of a woody or herbaceous matrix, or out of humus, or from among rotting leaves, are only the fructifications. The mycelium consists of hyphæ which branch profusely and permeate the tissues it attacks, or thread their way among humus, or over rotting leaves, etc., in a network of simple or compound filaments. In some of the parasitic *Polypores* it forms membranous cloth-like sheets in the wood. In the honey agaric—*Armillaria mellea*, it takes the form of black

brown, flat or roundish, lash-like, branched, strands of varying thickness; formerly this was considered to be a separate fungus, and called *Rhizomorpha*. In dry-rot it forms large, spreading, cottonwool-like cushions on the surface prior to the formation of its *hymenium* or spore-producing surface. In other instances it forms dense aggregations or hard knots of hyphæ known as *Sclerotia*. These are often intermediate stages between the filamentous mycelium and the sporophore.

In the Erysipheæ and other herbaceous plant parasites the mycelium envelops the exterior of the host and pushes through the epidermis organs of attachment or suction, haustoria or both, and thus taps the food supply the plant had made for its own consumption. In others the mycelium enters the host by means of the stoma, traverses the internal tissue, pierces the cell walls by means of short lateral branches, and develops haustoria within the cell. When the time arrives for the fungus to produce spores, or other means of reproduction, fertile hyphæ arise from the exterior mycelium in one case, and in the other find their way out through the stomata. Space does not allow further detail on these interesting phenomena.

There does not appear to be any doubt as to the capabilities of mycelial filaments to penetrate plant tissues, either herbaceous or woody, by the production of a ferment at their growing points. They can force their way into the hardest wood, and bring about its disintegration. Fallen twigs, leaves, etc., are rapidly reduced to humus by the mycelium of saprophytic species, and by other natural agents of decomposition.

Within the last few years other and better (?) employment has been claimed for "mycelium." The theory has been advanced that the cottony collection of mycelioid filaments enveloping the root tips of certain phanerogamic plants is of fungus origin, and that it materially assists its host or friend by extracting nitrogen from the soil and passing it to the receptive cells at the growing points of its roots; the higher plant in turn giving carbohydrates or other organised substances to the "mycelium." This is known as a form of symbiosis, or mutual exchange for the good of each.

As stated above, the sporophores or fructifications of fungi are almost infinite in their variety of external form. Being, however, classified by their reproductive elements, they are, with comparatively few exceptions, easily arranged in well-defined groups. The most clearly defined of these groups are the *Basidiomycetes*, *Uredinaceæ*, *Ascomycetes*, *Phycomycetes*, and *Myxomycetes*. In the Basidiomycetes the spores are produced on large specialized cells called *basidia*; a typical basidium is club-shaped in form, with two, four or more points—*sterigmata*—near the apex, each sterigma bearing one spore. The normal number of spores on each basidium is four, rarely two, or more than four. The basidia

are closely packed side by side, occasionally accompanied by other cells, and collectively form the *hymenium* or fructifying surface. Most of the larger fungi belong to this group, which includes the *Agaricaceæ*, *Polyporaceæ*, etc. In the *Agaricaceæ* —mushrooms and toadstools—the hymenium covers the whole surface of the gills. In the *Polyporaceæ* it lines the cavity of the pores. In the *Hydnaceæ* it covers the pendant teeth and other projections peculiar to this division. In *Clavariaceæ* it covers the whole surface of the clubs and their branches, above the stems, and in the *Thelephoraceæ* it covers the non-figurative, flat, or slightly indulating surface.

In the *Gastromycetes*, or puff-ball section, the basidia and spores are produced in cavities at first completely enclosed in a compact *peridium*.

The *Uredinaceæ* are a group of parasitic fungi of very destructive propensities. From an economic standpoint they are the most destructive of all. They cause an immense loss annually by destroying, or rendering unmarketable, much grain of various kinds. Numerous cereals, as well as other grasses and flowering plants, are subject to the attacks of the various members of this group in all parts of the world. In Britain alone, upwards of 360 British plants are preyed upon by them. They are well known to all observers of plant life. Their essential elements are spores and mycelium, the latter being confined to the interior of the plant. The spores burst through the epidermis of the leaves and stems in little yellow or brown pustules. Most of these plant parasites lead a pleomorphic existence, appearing under three or four different forms, producing as many different kinds of reproductive organs—*æcidiospores* (cluster-cups,) *uredospores* and *teleutospores*—and many make use of more than one host plant in going the whole round of their life cycle. Approximately, the *æcidiospores* occur in spring, the *uredospores* in summer, and the *teleutospores* in autumn, but each can overlap either way. The *teleutospores* develop a thick coat so as to enable them to tide over the winter. The too well known wheat-rust *Puccinia graminis* makes use of the barberry and the wheat plant on which to complete its life cycle; it is now thought, however, that it can dispense with the barberry, if need be, and get along without its aid as a host. The detailed processes of the various stages may be found in many good botanical text-books. To discuss this group further would be overstepping the intention we set out with—that of roughly indicating the features by which each group might be known to beginners, or to enable those who have no intention to trouble with fungi, to form some little idea of the important part they play in the economy of nature.

The *Ascomycetes* are characterized by the spores being produced in a kind of inverted hyaline membranous "bottle" or *ascus*. The asci are closely embedded, side by side, among other more

slender and often septate structures known as *paraphyses*; these, together, form the hymenium. *Pyrenomycetes* and *Discomycetes* are the principal sections of this group. There are several others —*Hysteriaceæ*, *Perisporiaceæ*, etc.—but these two suffice for our present purpose. The type of structure exhibited by the first group in their fructifications is "pear-shaped," hence *Pyrenomycetes* or pear-shaped fungi. They are mostly of minute size. The hymenium lines the cavity, a pore at the apex providing for the escape of the ripe spores. Often the asci, still containing the spores, are pushed bodily out of the aperture by the force of the development of younger asci below. The *perithecia* may be solitary or they may be semi-immersed in a compound structure—stroma —according to the species. Typical *Discomycetes* are saucer-shaped, or appear as flat "discs," the hymenium covering the disc up to its margin. Fructifications of different species vary in each direction from the type. In one direction there is a gradual approach to an almost globose or a bowl-shape, the margin forming a mouth less than half the diameter of the bowl. In the other direction there are species which appear to have turned themselves inside out and are quite clavate as in the genus *Geoglossum*—formerly known as Clavarias—Mitrula, Morchella, etc. There are numerous species possessing intermediate forms between these and the type.

In the *Hysteriaceæ* the mouth is long and narrow.

In the *Perisporiaceæ* the asci are completely enclosed, and the spores are not liberated until the disintegration of the ascophore or fruit-case.

The *Phycomycetes* are nearly all minute fungi, mostly appearing as white or coloured filmy moulds. The mycelium is copiously branched, and usually without dividing walls. Most of this group possess both sexual and asexual organs of reproduction, which vary more or less in structure in each of the six families. The group includes both parasitic and saprophytic species. Some are aerial, others aquatic, in habit. The parasitic species live in the tissues of flowering plants (as in the case of the potato disease, etc.). Even such plants as the duck-weed, floating on ponds, do not escape, neither do the fresh water algæ—Chara, Nitella and Spirogyra—are all subject to the attacks of parasitic fungi. Other fungi are also attacked by them. One or other of this section attacks and kills insects of various kinds, including house flies, aphides, etc. The saprophytic species find a home on all kinds of decaying animal, insect or vegetable substance, both aerial and submerged.

The *Myxomycetes* are so unlike other fungi in general aspect and development that they have been claimed for the animal kingdom by some authors. When a spore germinates, the contents leave the spore case and creep about in an amoeboid manner. These congregate in quantity. In this stage they move about

in thin, slimy masses—plasmodium—in the interstices of rotten wood, or damp, decaying leaves, in search of food. They finally come to rest on the surface and build up their fructifications—sporangia. These vary much in size and form. In some species they are almost as large as the egg of a barndoor hen, in others about the size of a pin head. The sporangia may be single, or a combination of many. A typical sporangium consists of wall, spores, and a network of thick or thin threads—capillitium. This group appears to be on the boundary line between the animal and vegetable kingdoms.

It has been impossible to give more than a very superficial survey of this vast subject in so short an article. Several sections, as the *Hyphomyces*, *Deuteromycetes*, etc., have not even been mentioned. There are numerous interesting sides of the subject, any one of which would furnish ample material for a separate paper, viz. :—Aims and Methods of Study ; Affinities with Algæ and Lichens ; Individual species : almost any ; Collecting and Preserving ; Drawing and Photographing, etc., etc. The working out of the life history of these organisms when it can be properly conducted, is the most valuable and entertaining feature of mycological study.

Bibliography :—Though this branch of botany is comparatively so little known, there has been no lack of Brtish literature, either popular or technical, dealing with the subject. Of the former type there appeared in 1857, M. J. Berkeley's " Introduction to Cryptogamic Botany" (including Fungi); in 1862, M. C. Cooke's " Plain and Easy Account of British Fungi"; in 1875, Cooke and Berkeley's "Fungi : their Nature, Influences and Uses"; and in 1895, Cooke's " Introduction to the Study of Fungi." On the technical side, James Bolton published the first British book entitled " History of Fungesses Growing about Halifax " (with coloured plates), 1788-1791 ; then followed " Sowerby's Drawings of English Fungi," London, 1797-1809 ; S. F. Gray's " Natural Arrangements of British Plants," 1821 ; J. E. Smith's " English Flora " (Vol. 5, Part II., Fungi by M. J. Berkeley, 1836 ; Berkeley and Broome's " Notices of British Fungi in Ann. Natural History," 1840-1883 ; Berkeley's "Outlines of British Fungi," 1860 ; Cooke's "Handbook of British Fungi," 1871 ; and " Illustrations of British Fungi (Hymenomycetes) " 1881-1891 ; Stevenson's " British Fungi (Hymenomycetes)," 1886 ; Philips' " Manual of British Discomycetes," 1887 ; G. Massee's " Monograph of the British Gastromycetes," 1889 ; Plowright's " Mon. Brit. Uredineæ," 1889 ; Massee's " Phycomycetes and Ustilagineæ," 1891 ; " Mon. Myxogastres," 1892 ; " British Fungus Flora," 1892-1895 ; and Lister's " Mon. of the Mycetozoa," 1894. Besides the above, several British treatises and English translations of continental works, treating the subject from an economic standpoint have, from time to time, been issued, *e.g.*, " Diseases of Field and Garden Crops," by Worthington

G. Smith; "Diseases of Plants," by H. Marshall Ward; "Plant Diseases," G. Massee; "Diseases of Trees," R. Hartig; Translated and Edited by Somerville and Ward, 1894; Tebeuf's work, Trans. by W. G. Smith. A text-book, the mention of which should not be omitted, is De Bary's "Comparative Morphology and Biology of the Fungi, Mycetozoa, and Bacteria," Eng. Trans., Oxford, 1887. On the lines it follows, this is at present the standard text-book. This magnificent work, still unapproached by any British author, was written more especially for advanced students, and supplied a much felt want in the higher grades of education. In the preface, the Professor, referring to the plan of his work, says, "I have endeavoured to make my remarks intelligible even to those who are only beginning the study of Fungi, but I have assumed that my readers are masters of such a previous general knowledge of botanical science as is to be obtained by a course of study in a University or by use of good text-books . . ." Sach's "Text-book and Lectures," "Goebel's Outlines," etc. To those not already acquainted with Prof. De Bary's book I may say that it is attractive reading to any diligent botanical student, and is profusely illustrated.

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